ACRES & WATTS:

CONSIDERING SCALE & RENEWABLE ENERGY

DRAFT

for discussion on July 14, 2010

Kevin Sweeney

* Haas School of Business, UC Berkeley
* Consultant to Resources Legacy Fund & Energy Foundation

INVESTING IN RENEWABLE ENERGY

- Health & safety
- Job creation
- Energy from free raw materials
- National security
- Protect biodiversity by limiting climate change
- Prevent the worst effects of climate change

GREENHOUSE GASES (GHGs) & TEMPERATURE

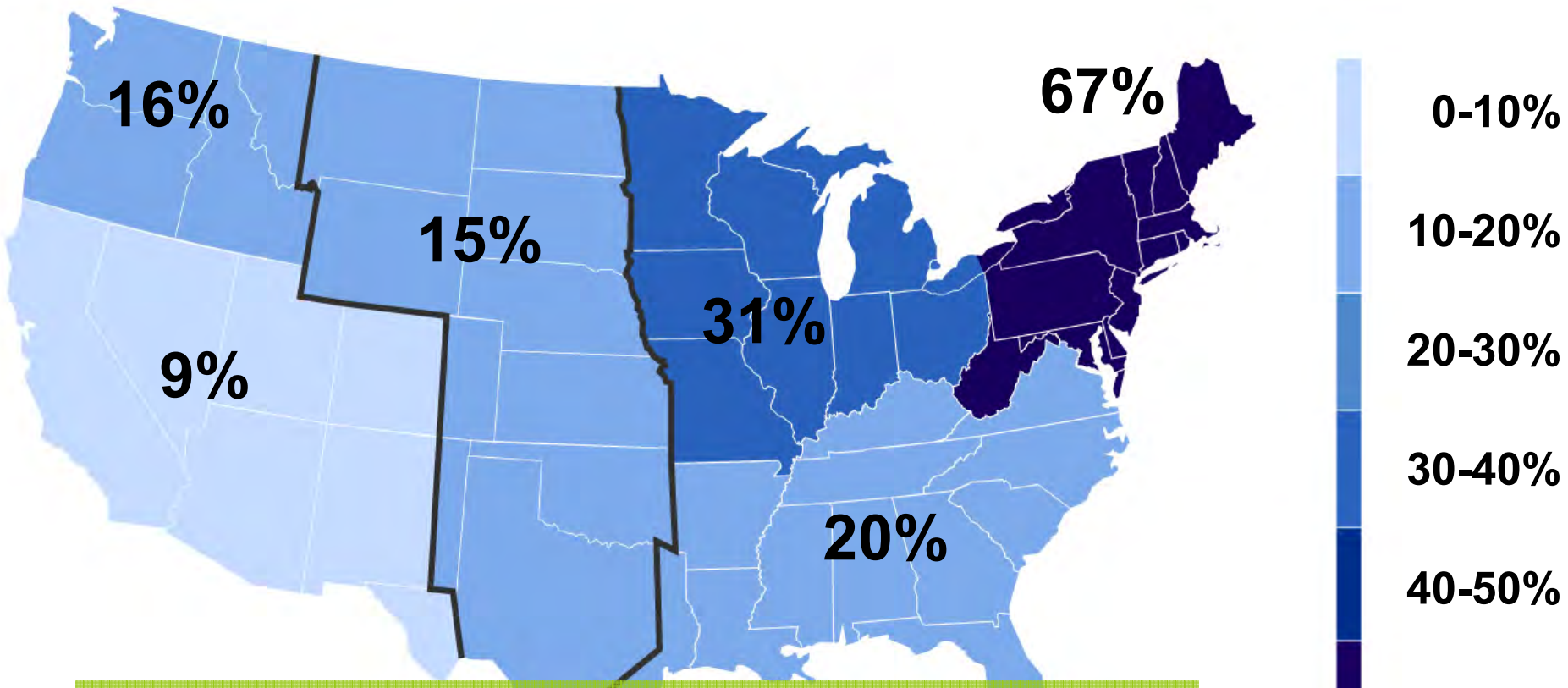
SOURCE FOR PROJECTIONS: IPCC FOURTH ASSESSMENT

- Before industrialization, atmospheric carbon was roughly 250 ppm
- Today, carbon is at roughly 400, and temps have increased 1.3ºF
- Some degree of additional increase cannot be avoided

* Temps represent middle of IPCC Fourth Assessment 5-95% projections

PAST CHANGES IN HEAVY PRECIPITATION EVENTS

Comparison: 1958 to 2007

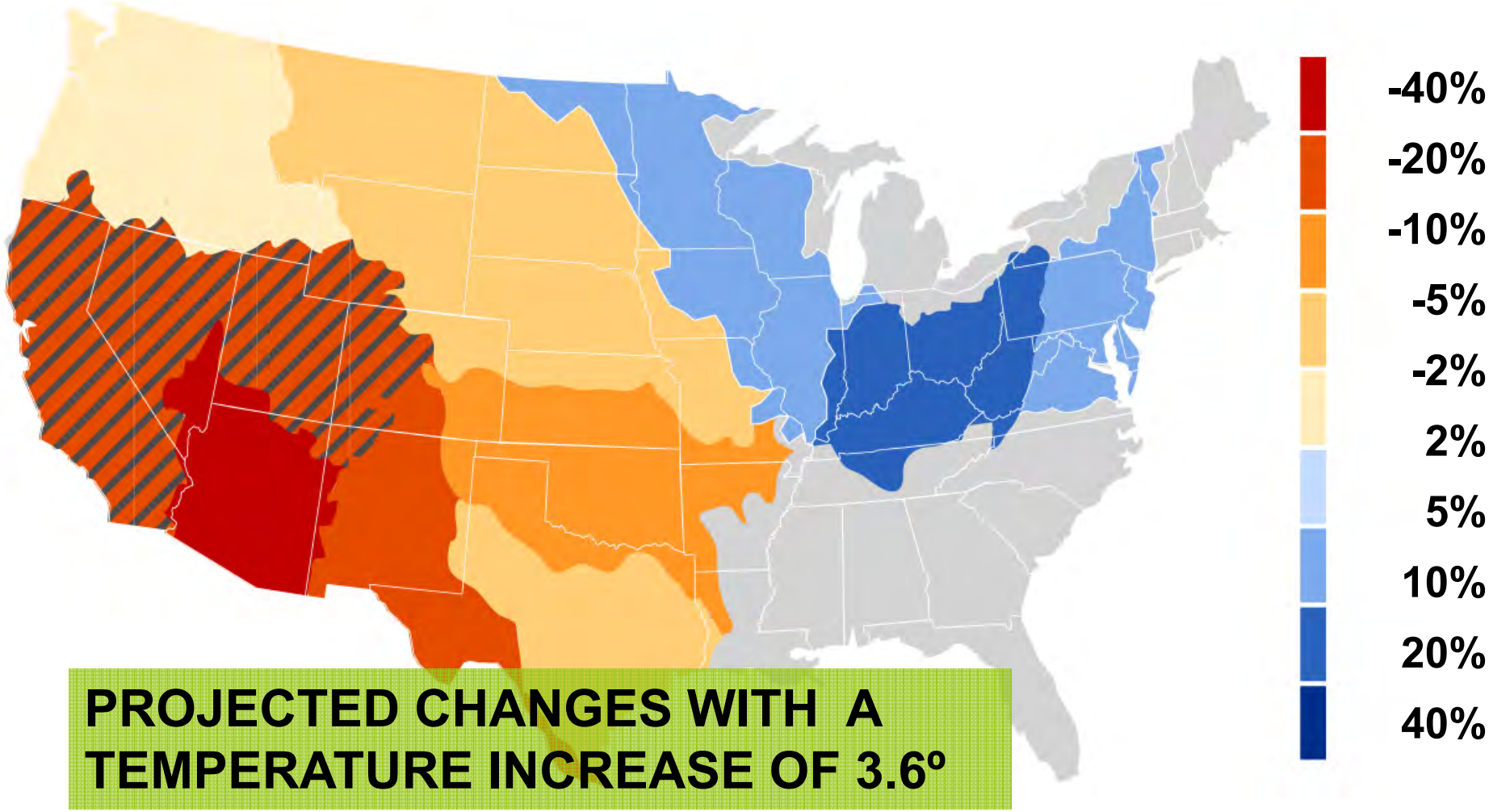


THESE CHANGES OCCURRED WITH A TEMPERATURE INCREASE OF 1.3º

Source: http://www.globalchange.gov

PROJECTED CHANGES IN RUNOFF

Projected changes in median runoff for 2041-2060. Baseline:1901-1970



PROJECTED CHANGES WITH A TEMPERATURE INCREASE OF 3.6º

Source: http://www.globalchange.gov

GREENHOUSE GASES (GHGs) & TEMPERATURE

SOURCE FOR PROJECTIONS: IPCC FOURTH ASSESSMENT

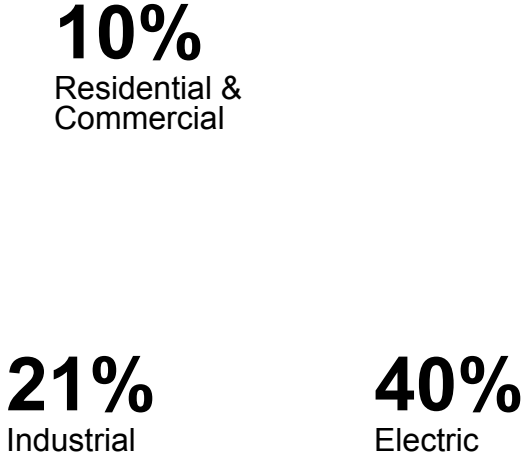
- Before industrialization, atmospheric carbon was roughly 250 ppm
- Today, carbon is at roughly 400, and temps have increased 1.3ºF
- If carbon stabilizes at 450, temps* are likely to increase a total of 3.6ºF (2ºC)
- If carbon stabilizes at 550, temps* are likely to increase a total of 5.4ºF
- If carbon stabilizes at 650, temps* are likely to increase a total of 7ºF

* Temps represent middle of IPCC Fourth Assessment 5-95% projections

McKINSEY & COMPANY: PATHWAYS TO A LOW-CARBON ECONOMY

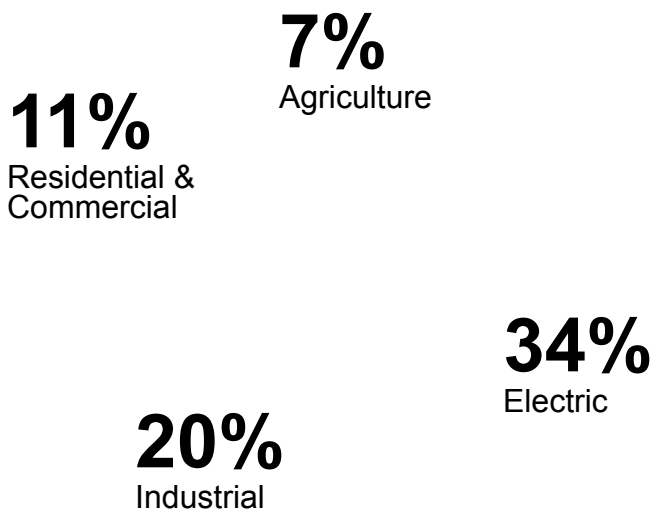
- "A 10-year delay in taking abatement action would make it virtually impossible to keep global warming below 2 degrees Celsius."
- "Our model shows that if global abatement action were to start in 2020 instead of 2010, it would be challenging to achieve even a 550 ppm stabilization path."

U.S. ENERGY CONSUMPTION
(by sector, 2007)



Source: Institute for Energy Research, Data Source: EIA, AER 2007

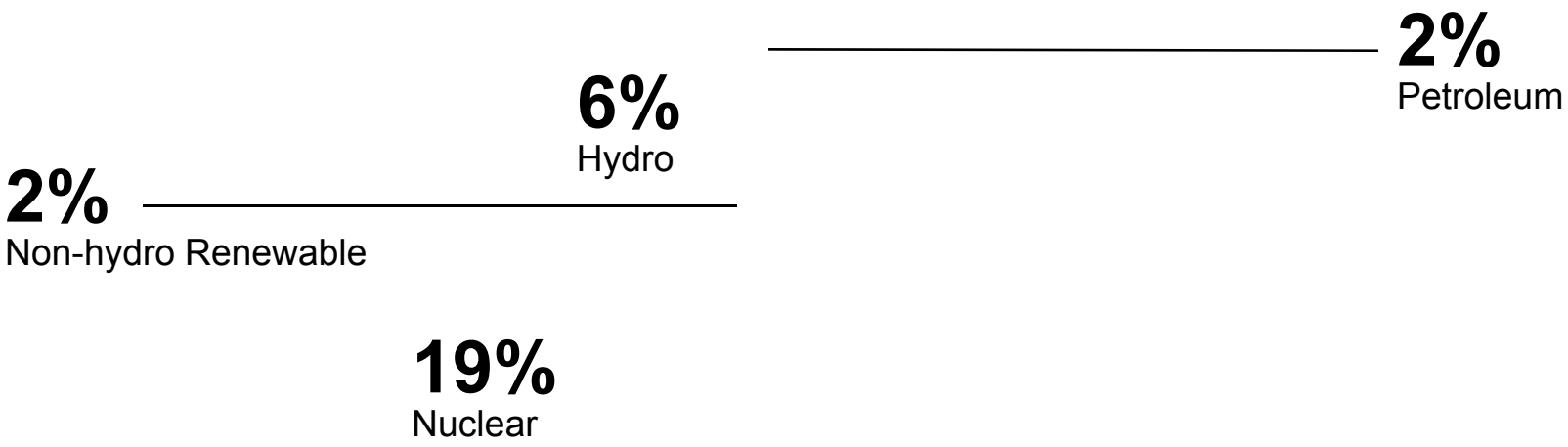
U.S. CARBON EMISIONS
(by sector, 2007)



Source: U.S. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, Table ES-7, 2009.

U.S. NET ELECTRICITY GENERATION

(by energy sector, 2007)



Source: Energy Information Administration (EIA), *Annual Energy Review 2007*, Table 8.2a, 2008 via Pew Center.

NATIONAL ENERGY & CLIMATE SCENARIOS

- Repower America (Al Gore)
  - 100% clean electricity by 2020
  - Retain, but don't expand, existing hydro and nuclear
  - Use solar and wind power to replace all electricity from coal and natural gas – achieving carbon-free electricity
- Union of Concerned Scientists
  - 33% savings from efficiency
  - Heavy investments in renewable energy
  - Cuts U.S. emissions from 2005 levels by 26% by 2020
  - Cuts U.S. emissions from 2005 levels by 56% by 2030

NATIONAL ENERGY & CLIMATE SCENARIOS

- Google Clean Energy 2030
  - Eliminate all electricity from coal, use 50% less natural gas
  - Begin converting transport fleet to plug-in hybrids
  - Cuts U.S. emissions from current levels by 41% by 2030
- McKinsey & Company
  - Stress efficiency &lifestyle changes; note cost effectiveness
  - Stress the need for a diversified approach
  - Cuts U.S. emissions from 2007 levels by 30% by 2030
- Pickens Plan
  - 22% of US electricity from wind power by 2020
- US DOE Wind Energy Study
  - 300 GW (20% of projected demand) by 2030

SAMPLE SCENARIO: GOOGLE 2030

WHAT IT ACHIEVES

88% less fossil fuel used to produce

95% less carbon emissions from electricity

45% less emissions from vehicles

41% less emissions overall

NATIONAL

DRAFT

SAMPLE SCENARIO: GOOGLE 2030

WHAT IT <u>REQUIRES</u>:

Energy Efficiency

Distributed Generation

Plug-in HEVs in 2030

- **90%** of new cars in 2030
- **41%** of overall fleet

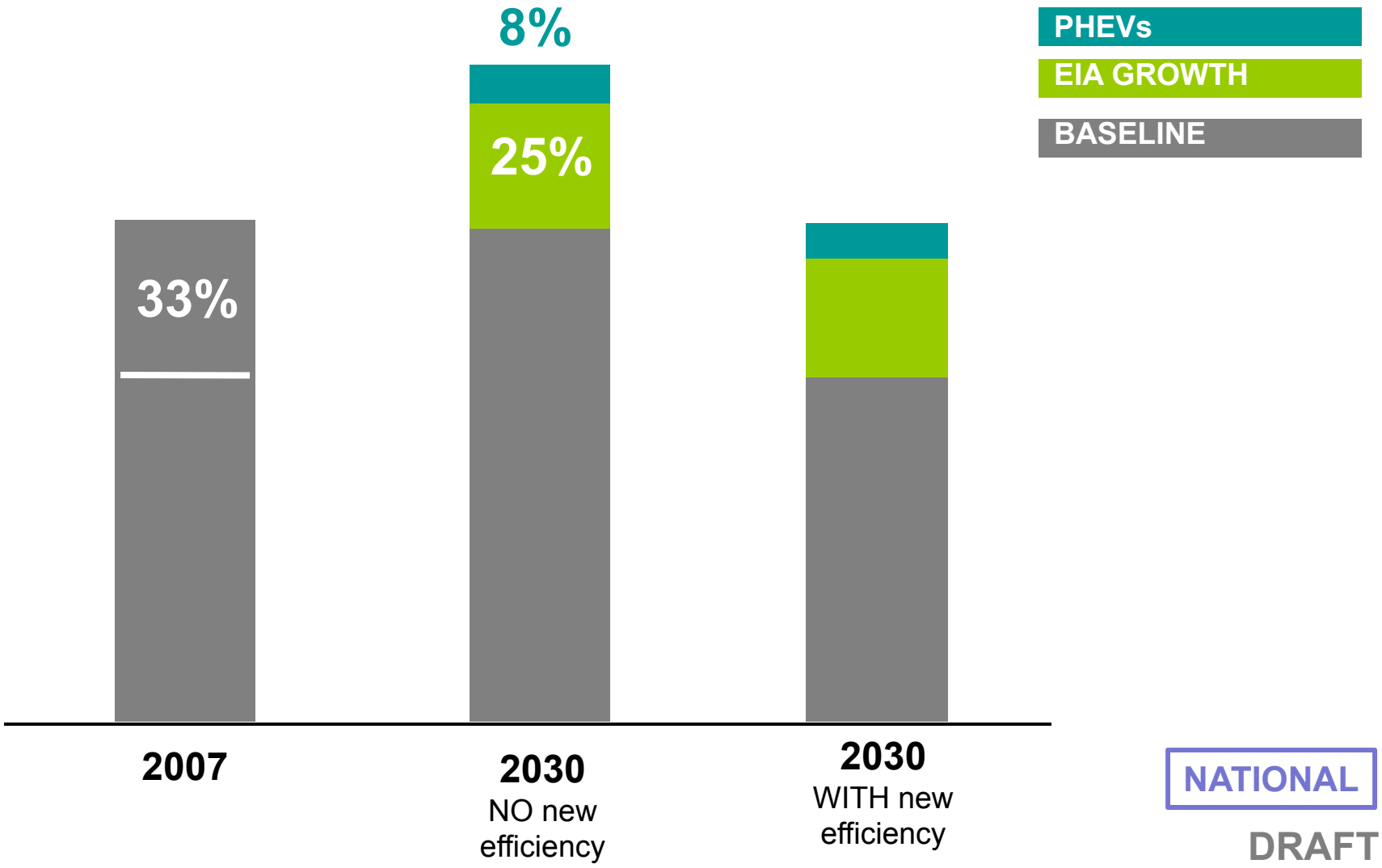
Use renewable energy to:

- Replace **all** coal
- Replace **half** natural gas

NATIONAL

DRAFT

SAMPLE SCENARIO: GOOGLE 2030
INVESTING IN EFFICIENCY

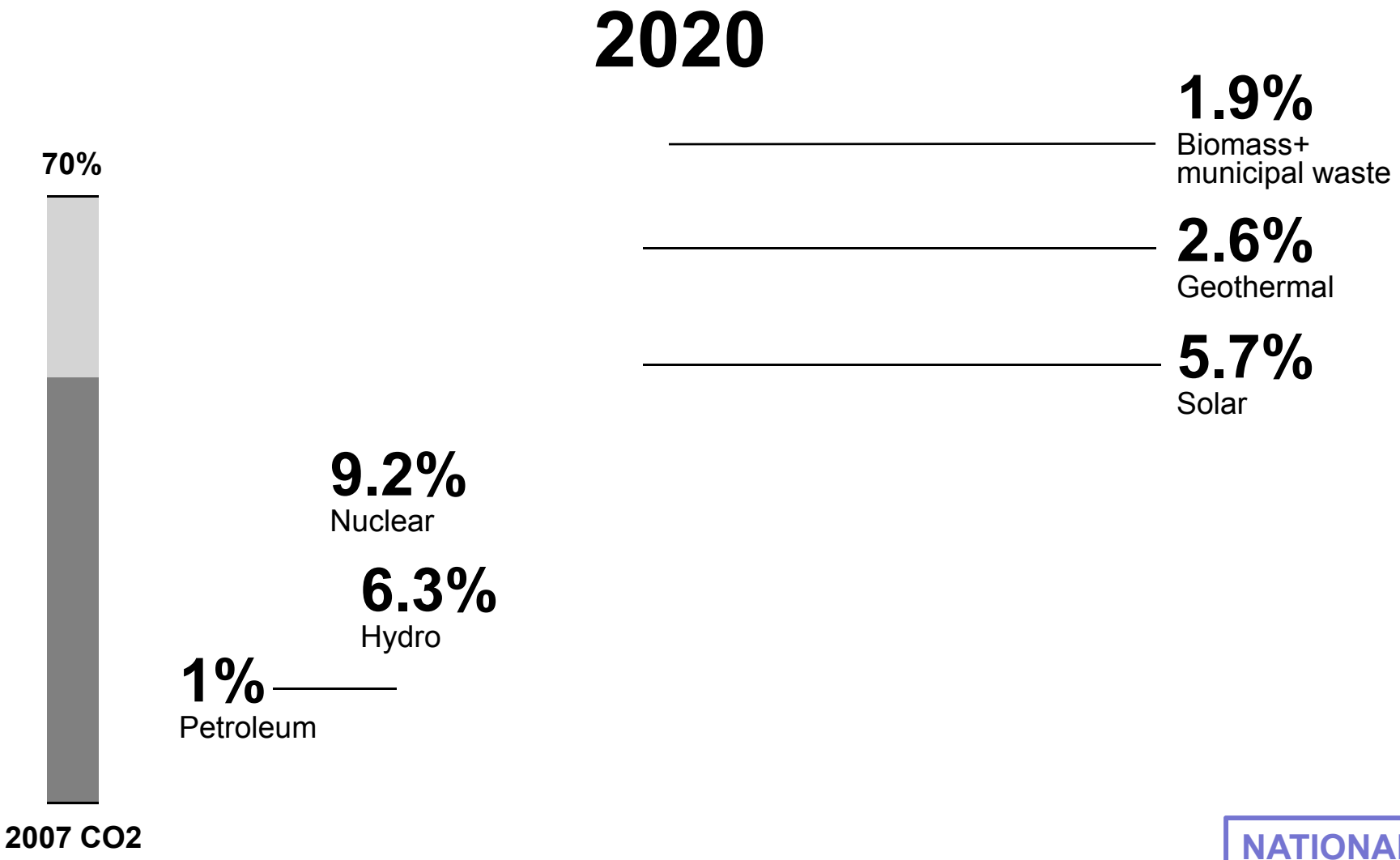


NATIONAL

DRAFT

GOOGLE 2030

U.S. ELECTRICITY MIX



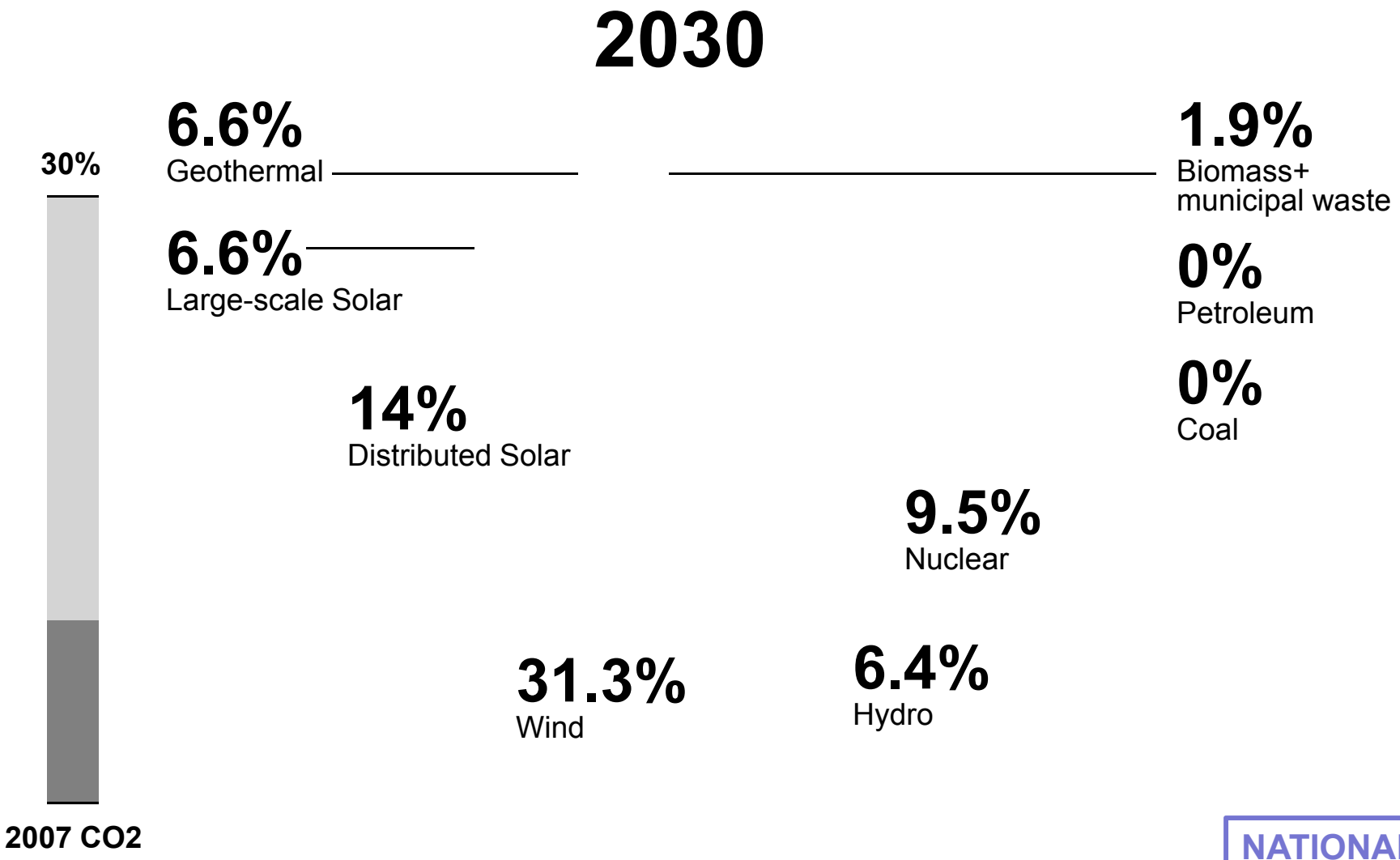
NATIONAL

Source:

DRAFT

GOOGLE 2030

U.S. ELECTRICITY MIX



NATIONAL

Source:

DRAFT

GOOGLE 2030

DISTRIBUTED GENERATION

170 GW of Distributed Generation solar PV:

85GW

from 35 million residential rooftops

85GW

from commercial rooftops

15%

of projected electricity demand for 2030

GOOGLE 2030

DISTRIBUTED GENERATION

170 GW of Distributed Generation solar PV:

25% of residential rooftops – **for the entire U.S.**

2.6% is the highest current concentration of rooftop PV for **a single U.S. city**

SAMPLE SCENARIO: GOOGLE 2030

UTILITY SCALE RENEWABLES

GOALS:

(In addition to **170 GW** from distributed generation)

300 GW	WIND
80 GW	OFFSHORE WIND
80 GW	LARGE-SCALE SOLAR POWER
65 GW	ENHANCED GEOTHERMAL
15 GW	CONVENTIONAL GEOTHERMAL
540 GW	UTILITY-SCALE RENEWABLE

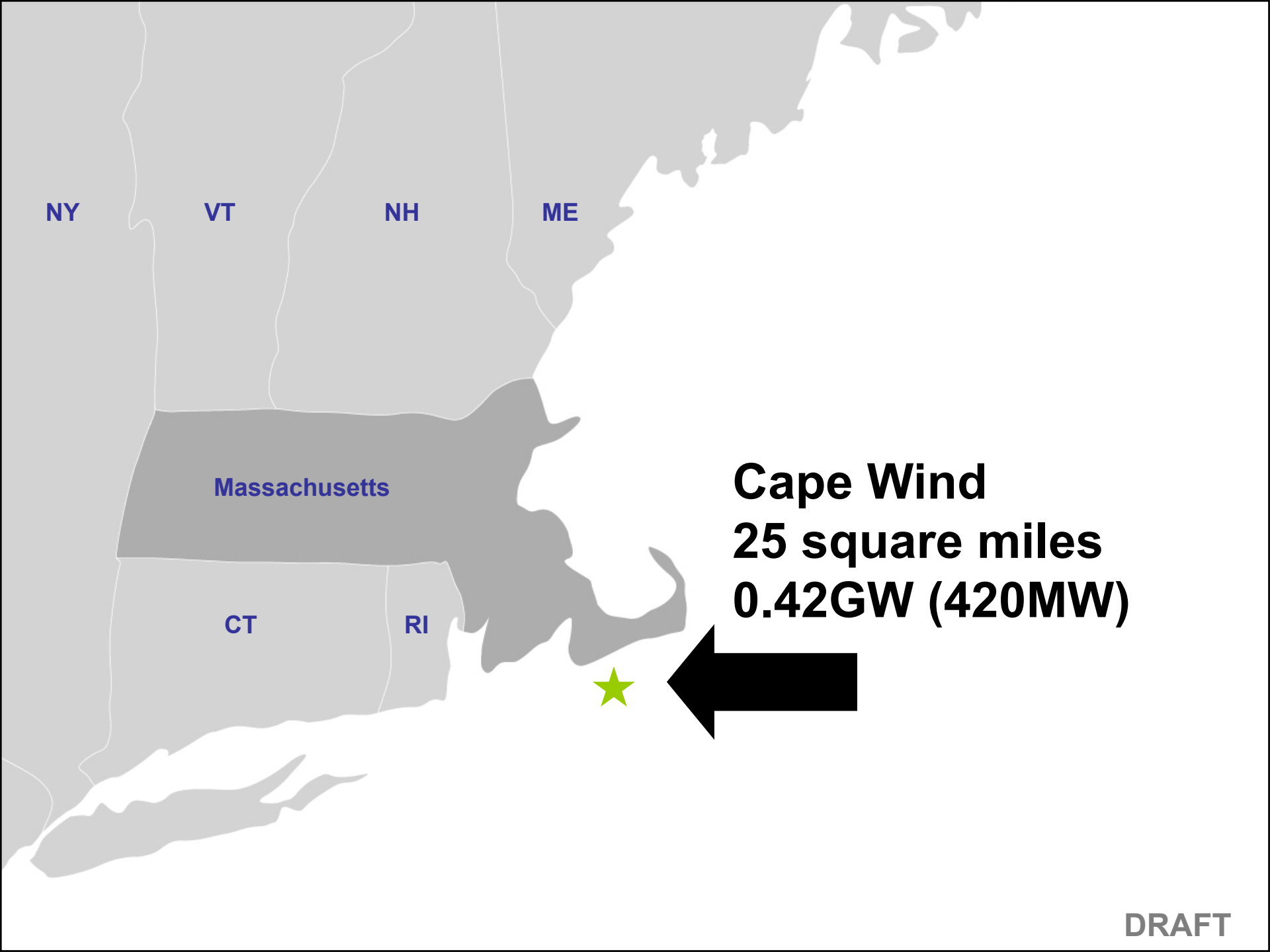
*__328 GW__ is current coal plant capacity

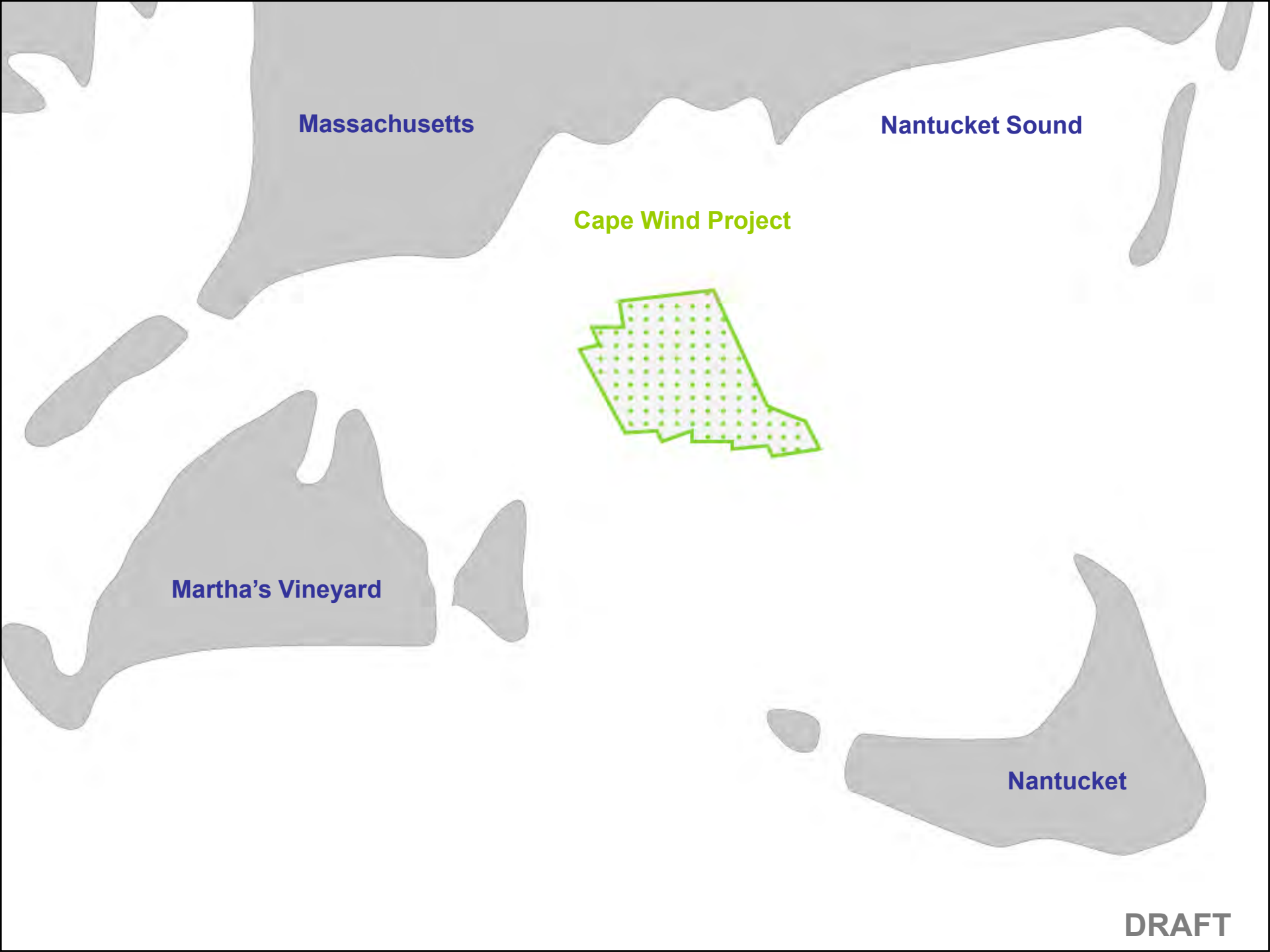
DRAFT

CONSIDERING SCALE:

80 GW

SAMPLE NATIONAL TARGET
OFFSHORE WIND


NY
VT
NH
ME
Massachusetts
CT
RI
Cape Wind
25 square miles
0.42GW (420MW)


Massachusetts
Nantucket Sound
Cape Wind Project
Martha's Vineyard
Nantucket

DRAFT

190 @ .42GW

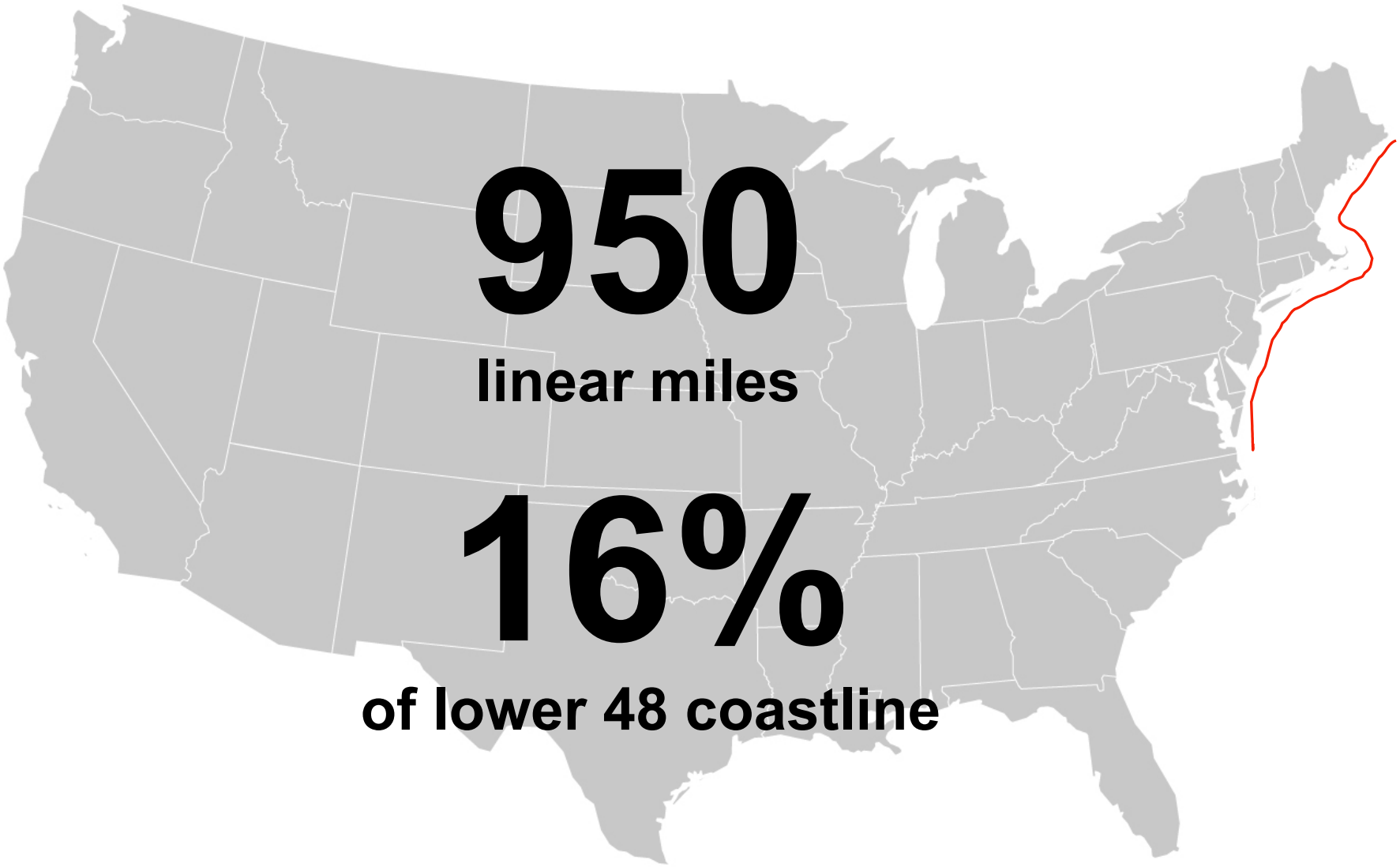
WIND FARMS

CAPACITY

80

GIGAWATTS

DRAFT



950

linear miles

16%

of lower 48 coastline

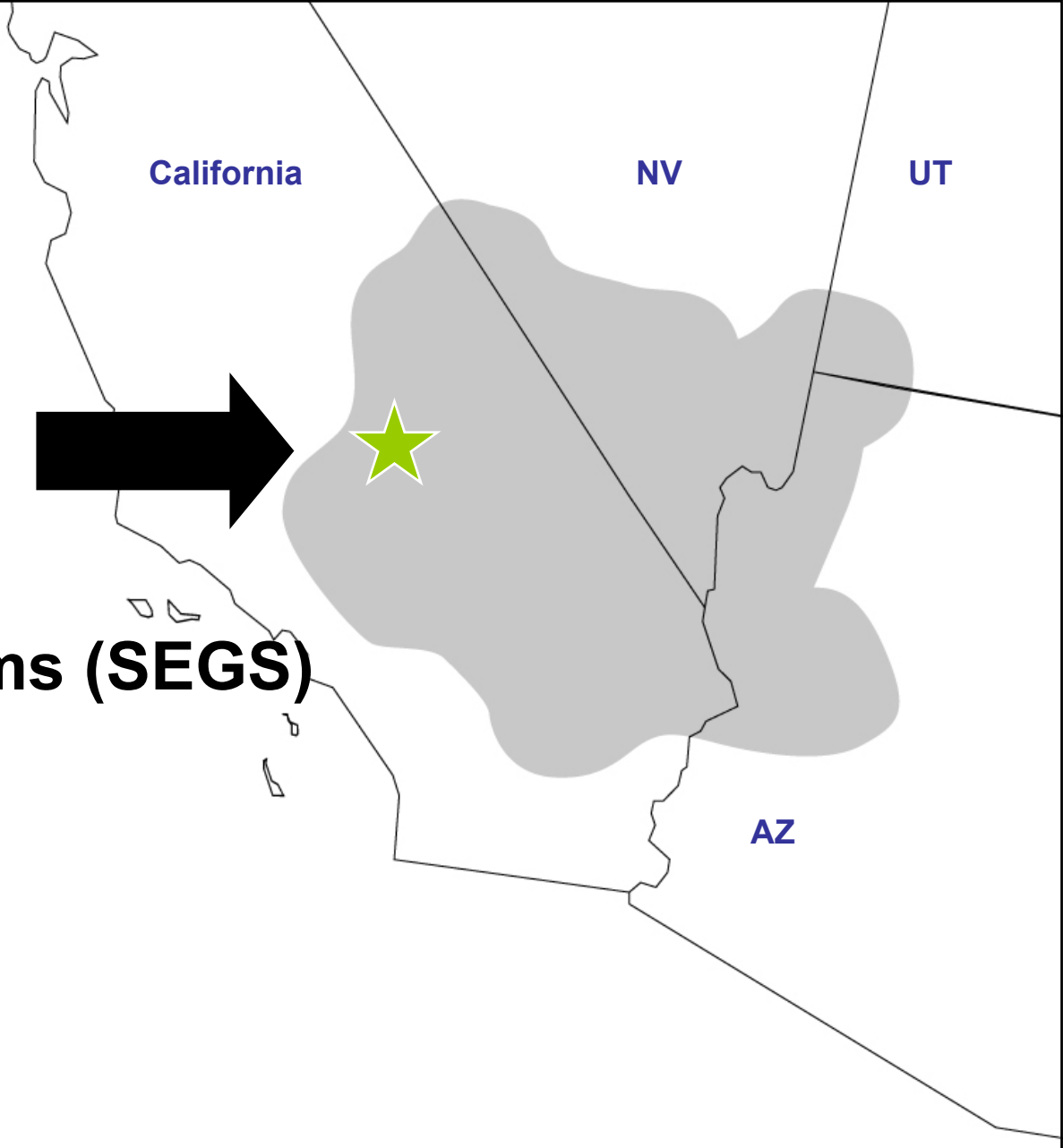
May 2 closure: 6,800 square miles

June 2 closure: 88,502 square miles

CONSIDERING SCALE:

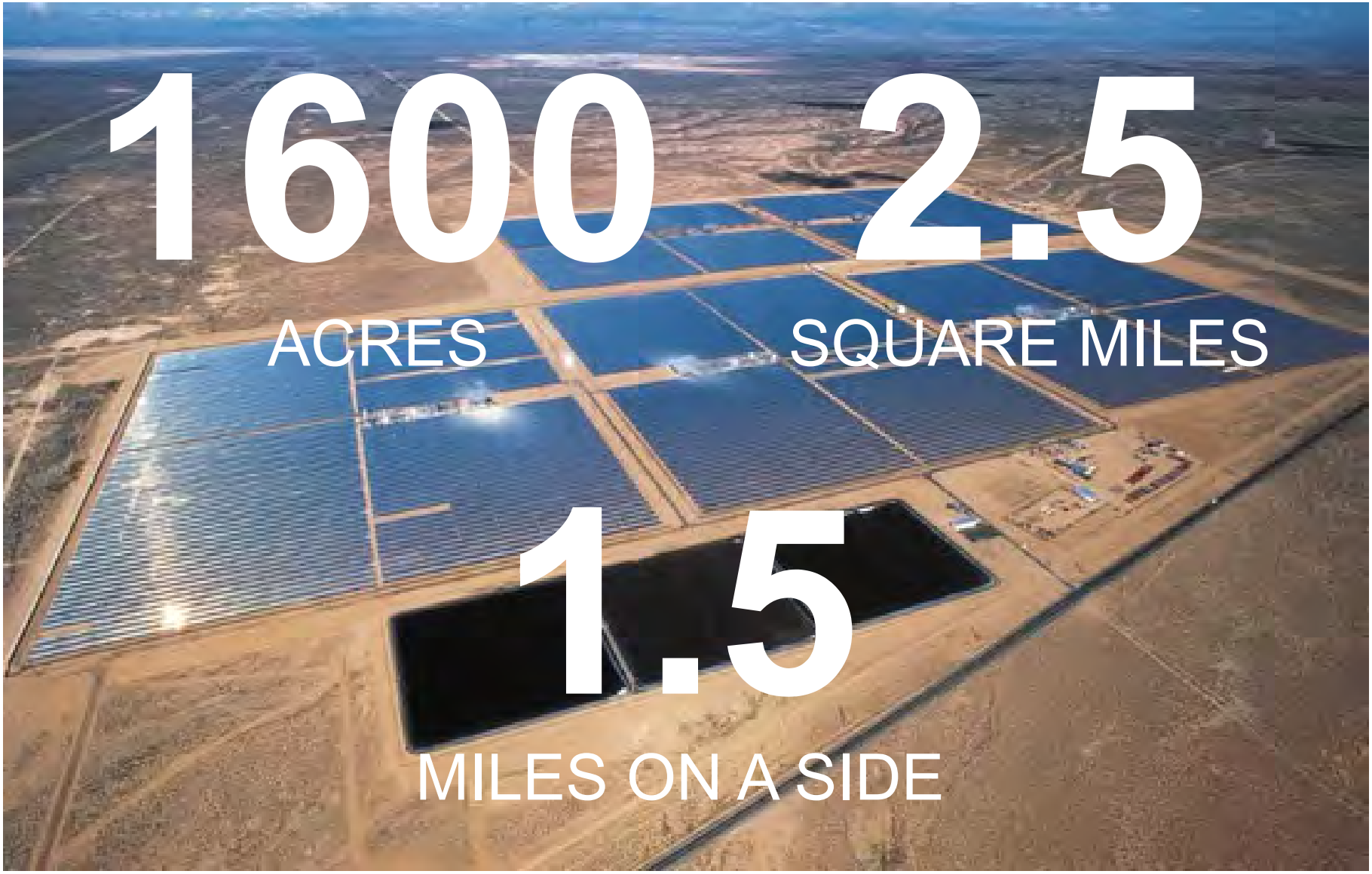
80 GW

SAMPLE NATIONAL TARGET
LARGE-SCALE SOLAR



Solar Energy Generating Systems (SEGS)
1600 acres
0.354GW (354MW)

Source:



Source:

6 MILES TO WALK AROUND THE SITE

Source:

INDIVIDUAL SITE

PLANT (Technology)	GW	ACRES
Nevada Solar 1 (Troughs)	**.075**	**400**
SEGS (Troughs)	**.354**	**1,600**
Ivanpah (Solar towers)	**.392**	**3,500**
AV Solar (PV array)	**.230**	**2,100**

NATIONAL

Source:

	INDIVIDUAL SITE		SITES TO REACH 80 GW	
PLANT (Technology)	GW	ACRES	# OF SITES	# OF ACRES
Nevada Solar 1 (Troughs)	.075	400	1,065	426,000
SEGS (Troughs)	.354	1,600	225	360,000
Ivanpah (Solar towers)	.392	3,500	204	714,000
AV Solar (PV array)	.230	2,100	347	729,000
Average*				500,000

NATIONAL

Source:

500,000 Acres of CSP:

3% All in one place, it would take 3% of the Mojave Desert

1% One-third of it would take 1% of the Mojave Desert

.5% All of it would take less than half a percent of the 4 largest US deserts

NATIONAL

Source:

500,000 Acres of CSP:

3% All in one place, it would take 3% of the Mojave Desert

1% One-third of it would take 1% of the Mojave Desert

.5% All of it would take less than half a percent of the 4 largest US deserts

Other desert impacts:

5% 5% less rainfall in Great Basin under best IPCC scenario

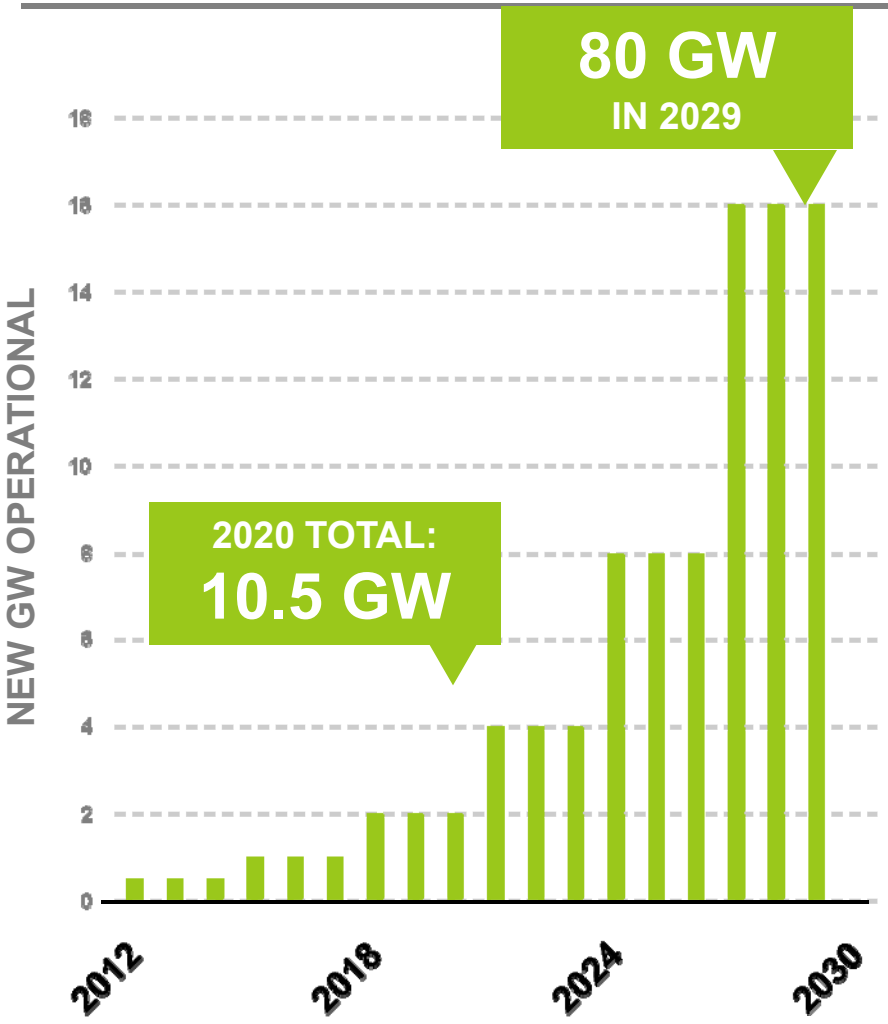
15% 15% less rainfall in the Great Basin under mid-range scenario

50% 50% of bird, mammal & butterfly species in the Chihuahua Desert in danger of being replaced by 2055

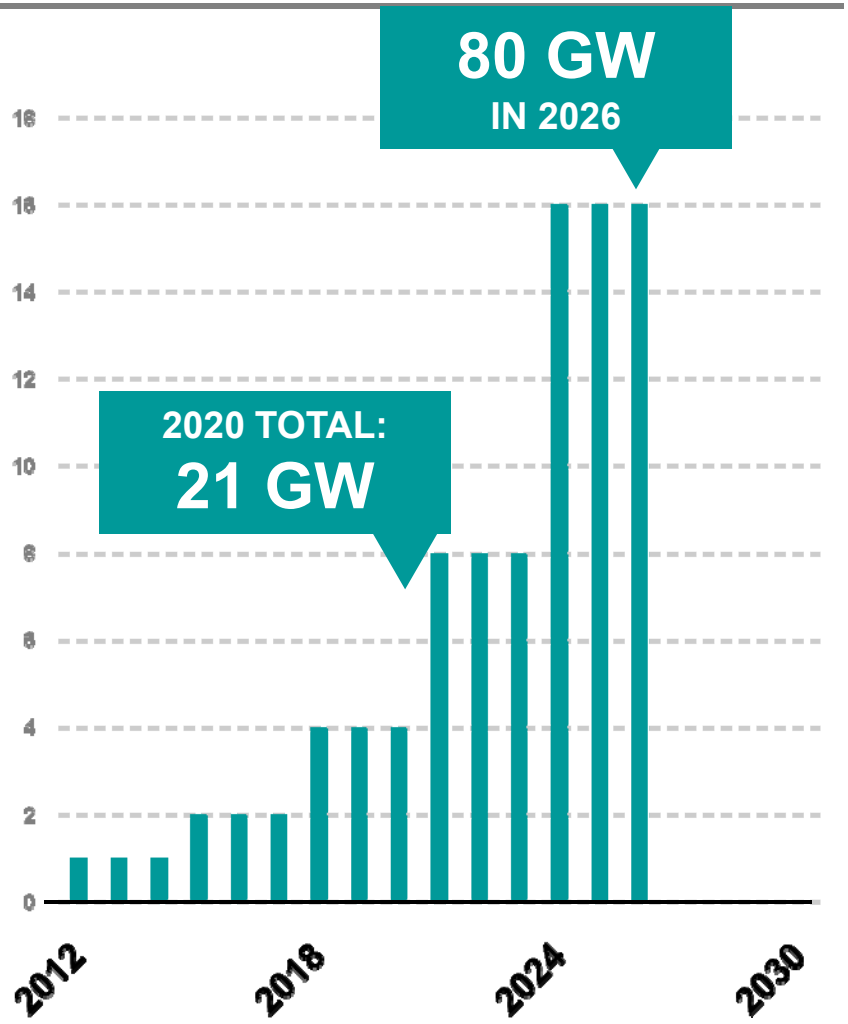
NATIONAL

Source:

ANNUAL GW INCREASE, DOUBLED EVERY 3 YEARS, STARTING AT .5 GW



ANNUAL GW INCREASE, DOUBLED EVERY 3 YEARS, STARTING AT 1 GW



DRAFT

CONSIDERING SCALE:

8 GW

SAMPLE CALIFORNIA DESERT TARGET

LARGE-SCALE SOLAR

50,000 ACRES?

50,000 Acres of CSP:

1.5% It would be 1.5% of the military lands in the CA desert .

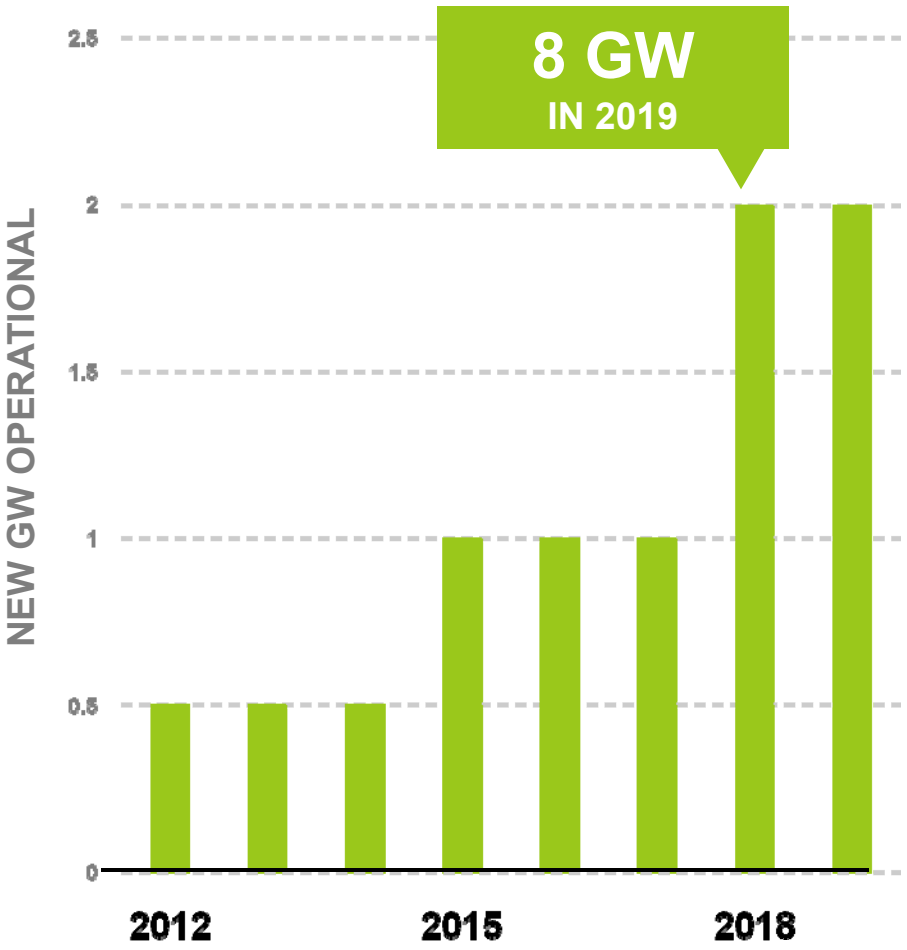
Other desert impacts:

15% 15% of the desert tortoises transported from Ft. Irwin were killed by coyotes.

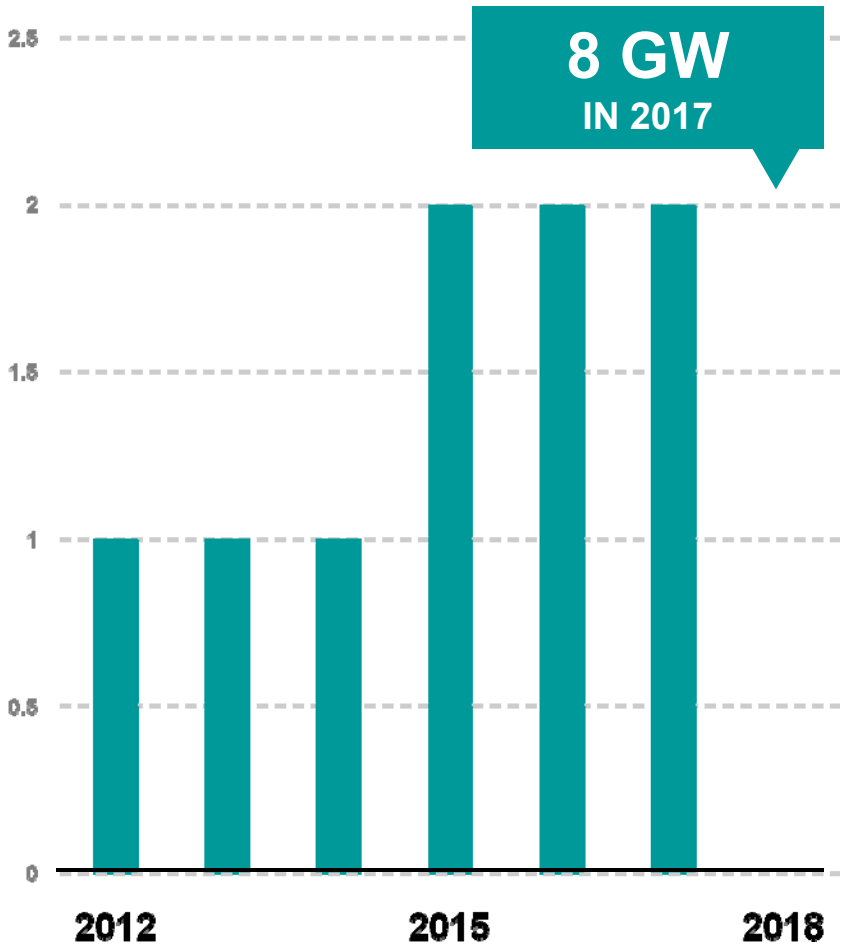
CALIFORNIA

Source:

ANNUAL GW INCREASE, DOUBLED EVERY 3 YEARS, STARTING AT .5 GW



ANNUAL GW INCREASE, DOUBLED EVERY 3 YEARS, STARTING AT 1 GW



DRAFT

CONSIDERING SCALE:
WHEN RAINFALL CHANGES

↑ **40%** **Los Angeles would have the rainfall of San Francisco**

↓ **20%** **Portland would have the rainfall of San Antonio**

↓ **40%** **San Francisco would have the rainfall of Tucson**

GENERAL GORDON R. SULLIVAN (RET.)
FORMER CHIEF OF STAFF, U.S. ARMY

ON ACTING WITH INCOMPLETE INFORMATION:

We seem to be standing by and, frankly, asking for perfectness in science. People... want to know the climate science projections with 100 percent certainty. Well, we know a great deal, and even with that, there is still uncertainty. But the trend line is very clear.

We never have 100 percent certainty. We never have it. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield. That's something we know. You have to act with incomplete information.

CONSIDERING SCALE: MULTIPLE FUTURES

What is your GW target? Why?

What is your timeline for hitting that target? Why?

Is your focus on California's 33% target? Are you considering additional goals? Why or why not?

What is your strategy for working with incomplete information?

With climate change, does "somewhere else" exist?